EFFICIENCY AND CAPACITY TESTS
OF A
SMALL GASOLINE - ELECTRIC SET

BY

H. HIMELBLAU

ARMOUR INSTITUTE OF TECHNOLOGY

1914

621.43
H 57

Illinois Institute
of Technology
UNIVERSITY LIBRARIES

AT 340
Himelblau, H.
Efficiency and capacity
tests of a small

For Use In Library Only

EFFICIENCY *and* CAPACITY TESTS OF A SMALL GASOLINE-ELECTRIC SET

A THESIS

PRESENTED BY

HARRY HIMELBLAU

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

MAY 28, 1914

G. F. Gebhardt

H. M. Raymond

L. C. Monin

ILLINOIS INSTITUTE OF TECHNOLOGY
PAUL V. GALVIN LIBRARY
35 WEST 33RD STREET
CHICAGO, IL 60616

621.43
H57

INDEX

Page

I. Introduction.

1. Object 1

2. Place 1

II. Engine.

1. Governor 2

2. Ignition 3

3. Prony Brake 3

4. Clearance Volume 3

5. Preliminary Runs 3

6. Valve Setting 4

III. Generator.

1. Apparatus 5

2. Tests 5

IV. Fly-Wheel

1. Description 6

2. Tests 6

24856

INDEX -#2

Page

V. Approximate Actual Cards

1. Compression 7
2. Theory 8

VI. Calculations

1. Approximate Actual Cards 8
2. Excess Energy 11
3. Fly-Wheel 11
4. Brake Load 1 13
5. Electric Load 3 14
6. Fly-Wheel Load 1 15

VII. Conclusions 16

LIST OF ILLUSTRATIONS

Page

Fig. 1. Ignition System 17

Fig. 2. Compound Generator Winding 18

Fig. 3. Approximate Actual Cards 19

Fig. 4. Fly-Wheel 20

Logs and Results

Fig. 5. Brake Load 1 21

Fig. 6. Brake Load 2 22

Fig. 7. Electric Load 3 23

Fig. 8. Electric Load 4 24

Fig. 9. Fly-Wheel Load 1 25

Fig. 10. Fly-Wheel Load 2 26

Fig. 11. Fly-Wheel Load 3 27

Fig. 12. Fly-Wheel Load 4 28

Fig. 13. Fly-Wheel Load 5 29

Fig. 14. Fly-Wheel Load Ave. 30

Curves

Page

Fig. 15. Brake Load 1 31

Fig. 16. Brake Load 2 32

Fig. 17. Electric Load 3 33

Fig. 18. Electric Load 4 34

Fig. 19. Fly-Wheel Load 1 35

Fig. 20. Fly-Wheel Load 2 36

Fig. 21. Fly-Wheel Load 3 37

Fig. 22. Fly-Wheel Load 4 38

Fig. 23. Fly-Wheel Load 5 39

Fig. 24. Fly-Wheel Load Ave. 40

Fig. 25. Photograph 41

Fig. 26. Photograph 42

EFFICIENCY AND CAPACITY TESTS
OF A
SMALL GASOLINE - ELECTRIC SET.

OBJECT

The purpose of this thesis is to determine the gasoline consumption and the mean effective pressures of a small gasoline engine. By a series of tests the effect of keying a fly-wheel to the generator was noted.

The experiments were performed in the gas laboratory of the Mechanical Engineering Department of the Armour Institute of Technology.

ENGINE

The engine of the poppet valve type, with the valves in the head, was manufactured by the International Harvester Company. It is rated at one horse-power at 600 revolutions per minute. The diameter of the cylinder is 3-5/8", with a stroke of 3-15/32".

GOVERNOR

The speed of the engine is controlled by a governor operating on the "hit or miss" principle. The governor of the centrifugal type is suspended from the shaft of the fly-wheel. A bell-crank is actuated inward and outward by the action of the governor balls. The function of the bell-crank is to catch in the arm of the push-rod, actuating the exhaust valve, holding it open when the desired speed of 600 revolutions per minute has been exceeded. Air is then drawn into the cylinder on the intake strokes through the open exhaust valve until the speed is decreased sufficiently to allow the bell-crank to release its hold. The intake valve is automatic. The resistance on the valve is a light spring, the tension of which can be regulated by lock-nuts. When the governing mechanism holds the exhaust valve open, the intake valve remains closed.

IGNITION

The ignition of the engine is by battery and a coil, manufactured by the New York Coil Co., is used. One of the terminals of the coil is connected to the battery, the secondary is connected to the spark plug and the interrupter is grounded on the cylinder. The diagramatic outline of the ignition system is shown in Fig. 1, page 17.

PRONY BRAKE

The Prony brake is light in construction, consisting of two blocks sawed to fit a pulley fastened to the crank-shaft by set-screws. Holes for lubrication were drilled to prevent it from binding.

CLEARANCE VOLUME

The clearance was obtained by placing the piston on its head end, noting that both valves were closed and water tight. A known cubical content of water was poured into the clearance space, using a graduate.

PRELIMINARY RUNS

Before starting the runs, the engine was cleaned thoroughly. The valves were ground, and the tension of the springs operating them

was regulated. The gasoline tank was placed on a scale, which read to one-hundredth of a pound. The connection between the gas tank and mixing valve was made by a rubber tube. The mixing valve was removed and cleaned and the needle valve was adjusted. A few preliminary Prony brake runs were made.

VALVE SETTING

Increments of 10° were stamped on the rim of the fly-wheel, by means of a tape and plumb-bob. The time of opening and corresponding closing of the exhaust valve is regulated by a lock set-screw, in the rocker arm, which presses against the stem of the exhaust valve. By increasing its length the valve opens early. Runs were taken with the valve open 12° early and closing at 148°. A brake horse-power of 1.53 was obtained. The valve was allowed to be open earlier by increments of 10°, until 62° early and a 198° was obtained. The maximum brake horse-power in all trials remained approximately at 1.57. The best result obtained was with the valve opening at 50° early and

closing at 186°. Brake load tests I and II were then made. Pages 21 and 22 contain the tabulated data and pages 31 and 32 the plotted curves.

GENERATOR

The generator, numbered 19576, is compound wound with a voltage of 115/120 and amperage of 7, manufactured by Roth Bros. & Co., Chicago. The rated speed is 1650. The load on the generator was obtained by using a lamp-rack of sixteen incandescents connected in parallel. The voltage was controlled by a hand rheostat field regulator. A Weston voltmeter (0-300) was used across the line and a Weston ammeter (0-15) was placed in series. For diagram of generator winding and placing of instruments on the line,see Fig. 2, page

TESTS

Tests were made with the electric load, with increments of three lamps, from 0 to 13, but the results were plotted for a load of twelve lamps, as this was the maximum that the engine could carry. The runs were made with a duration of from 5 to 10 minutes for each load,

noting duration of run, amperes, volts, gasoline/per time, explosions per minute, and revolutions per minute of engine and generator.

FLY-WHEEL

A draw-back to the use of small gasoline engines operating with a "hit or miss" governor is the flickering of the lights which is caused by the voltage increasing and decreasing every time the engine hits or misses. In order to eliminate this annoyance a fly-wheel shown in Fig. 4, page 20 was designed, built, and keyed to the shaft of the generator. The shape of the wheel was designed to allow the mass to be concentrated over the bearing of the generator, thus eliminating excess heating. The available space for the placing of the wheel was limited by the flame of the generator. It was thus necessary to have it compact.

TESTS WITH FLY-WHEEL LOAD

The fly-wheel was keyed to the shaft of the generator and the belt was slipped over the pulley, forming the hub of the wheel. Five minute runs were made with increments of three

lamps. Duration of run, amperes, volts, gasoline/time, explosions per minute, and revolutions per minute of engine and generator were noted. It was readily noticed that the flywheel caused explosions per minute to become nearly constant, for each load and it steadied the speed of the engine, which transmitted through the belt to the generator gave a constant voltage on the line.

APPROXIMATE ACTUAL CARDS

As there was no indicator cock on the engine it became necessary to approximate a card. The clearance of the engine was obtained by the process described on page 3 and it was found to be .009 cu. ft. or 30.5%.

The compression pressure was obtained by inserting an indicator cock in the spark-plug hole and screwing on an indicator. The engine was turned over by hand and cards were taken. There was very little difference in the length of the lines under varying speeds. The average length of line was 1-3/8", and the spring used was 40#, making a compression pressure of 55#/sq. in. gauge.

The expansion and compression curves were assumed adiabatic, allowing the use of the following formula:

$$\frac{P}{P_1} = \left(\frac{V_1}{V}\right)^n$$

P_1 = known pressure #/sq. in. absolute.

V_1 = known vol. in cu. ft.

P = desired pressure.

V = vol. corresponding, to desired pressure.

n = constant for either compression or expansion.

CALCULATIONS FOR
APPROXIMATE ACTUAL CARDS

$$\frac{P}{P_1} = \left(\frac{V_1}{V}\right)^n$$

Compression

$P_1 = 55 + 14.7 = 69.7$# abs.

$V_1 = .009$ cu. ft.

$n = 1.35$

$$P = \frac{69.7}{\left(\frac{.015}{.009}\right)^{1.35}} = 34.9\# \text{ for } V = .015 \text{ cu. ft.}$$

$$P = \frac{69.7}{\left(\frac{.02}{.009}\right)^{1.35}} = 23.75 \text{ for } V = .02 \text{ cu. ft.}$$

Similarly:

P = 17.55 for V = .025 cu. ft.

P = 14 for V = .02955 cu. ft.

Expansion

$P_1 = 175$# abs. (assumed)

$n = 1.3$

$$P = \frac{175}{\left(\frac{.015}{.009}\right)^{1.3}} = 90.1\text{\# for } V = .015 \text{ cu. ft.}$$

Similarly:

$P = 62$# for $V = .02$ cu. ft.

$P = 46.4$# for $V = .025$ cu. ft.

$P = 37.2$# for $V = .02955$ cu. ft.

The points were plotted on the curve, page

The card was integrated with a planimeter.

Result:

Initial pressure = 175# abs.

Area of card = 1.7

Length of card = 2.04

$$\text{M.E.P.} = \frac{1.7}{2.04} = .833 \times 50 = 41.6\text{\#.}$$

$$\text{I.H.P.} = 41.6 \times 10.23 \times \frac{3.47}{12} \times \frac{300}{33000}$$

$$= 1.12.$$

This result was too low. Therefore an initial pressure of 220# abs. was assumed.

$P_1 = 220$# abs.

$n = 1.3$

$P = 113.5$# for $V = .015$ cu. ft.

$P = 78.$ # for $V = .02$ cu. ft.

$P = 58.$ # for $V = .025$ cu. ft.

$P = 47.2$# for $V = .02955$ cu. ft.

Result:

Initial pressure = 220# abs.

Area of card = 2.3

Length of card = 2.04

M.E.P. $= \frac{2.3}{2.04} \times 50 = 56.3$#/sq. in.

I.H.P. $= 56.3 \times 10.23 \times \frac{3.47}{12} \times \frac{300}{33000}$

$= 1.515.$

This result is also low as the efficiency is 100% of B.H.P. An initial pressure of 250# gauge was assumed.

$P_1 = 250$# abs.

$n = 1.3$

$P = 129$# for $V = .015$ cu. ft.

$P = 88.9$# " $V = .02$ cu. ft.

$P = 65.8$# " $V = .025$ cu. ft.

$P = 53.5$# " $V = .02955$ cu. ft.

Result:

Initial pressure = 250# abs.

Area of card = 2.04

M.E.P. $= \frac{3.03}{2.04} \times 50 = 73.25\#$ per sq.in.

I.H.P. $= 73.25 \times 10.23 \times \frac{3.47}{12} \frac{\times 300}{33000}$

$= \underline{2.0}$

This is an approximate actual card, as an efficiency of 75% of highest B.H.P. is allowed.

CALCULATIONS FOR EXCESS ENERGY

B.H.P. $= \frac{\text{Ft.\#/min.}}{33000} \times$ E.P.M.

B.H.P. x 33000 = Ft.#s energy x E.P.M.

$\frac{3}{4}$ Ft.#s energy = excess energy.

$1.5 = \frac{E \times \text{E.P.M.}}{33000}$

$E = \frac{1.5 \times 33000}{300} = 165$ ft.#s.

$e = \frac{3}{4} \times 165 = 123.5$ ft.#s.

CALCULATIONS FOR FLY-WHEEL

$W = \frac{ge}{dV^2}$.

W = weight wheel in #s.

V = vel. in ft./sec.

e = excess energy in ft.#s.

g = ft./sec.^{2}

d = % fluctuation.

$g = 32.2$

$e = 123.5$

$d = .01$

$V = 6.28 \text{ x } .5 \text{ x } \frac{1600}{60} = 83.5$ ft./sec.

$V^2 = 7000$

$W = \frac{32.2 \text{ x } 123.5}{.01 \text{ x } 7000} = 57\#.$

From Fig. #4, page 20.

$W = G \text{ x } A \text{ x } 2\pi r.$

A = area in sq. in. of rim.

G = distance center of gravity of rim to center of wheel.

$W = 6.28 \text{ x } 6 \text{ x } 6 \text{ x } \frac{450}{1728} = 59\#.$

These two weights check.

CALCULATIONS

Brake Load I

PAGE 21.

$$\text{B.H.P.} = \frac{2\pi rnP}{33000}$$

r = length arm in feet.

n = revolutions per minute.

P = load in #s.

Run I.

$$\text{B.H.P.} = \frac{2 \times 3.14 \times 11 \times 600 \times 14}{12 \times 33000} = \underline{1.465}$$

Gasoline #/H.R. = 2.1

$$\text{Gasoline \#/B.H.P./Hr} = \frac{2.1}{1.465} = \underline{1.435}$$

Explosions per min. = 300

$$\text{I.H.P.} = \frac{PLAE}{33000}$$

Assuming 100% efficiency:

$$1.465 = \frac{P \times 3.47 \times 3.14 \times 12.8 \times 300}{12 \times 4 \times 33000}$$

M.E.P. = $\underline{54.4}$#/sq.in. gauge.

Electric Load #3

Run I:

Amp. = 1.4

Volts = 105

K.W. = 1.4 x 105 = .147

E.H.P. = .147 x 1.341 = $\underline{.197}$

Gasoline #/Hr. = 1.08

Gasoline #/B.H.P./Hr. = $\frac{1.08}{.197} = \underline{5.48}$

Explosions per minute = 146.

Assuming 100% efficiency.

$$.197 = \frac{P \times 3.47 \times 3.14 \times 12.8 \times 146}{12 \times 4 \times 33000}$$

M.E.P. = $\underline{15.05}$#/sq. in. gauge.

FLY-WHEEL LOAD #I.

Fig. 9, page 25.

Run 5:

Amp. = 5

Volts = 104

K.W. = 5 x 104 = .520

E.H.P. = .52 x 1.341 = .696

Gasoline #/Hr. = 1.2

Gasoline #/B.H.P./Hr. $= \frac{1.2}{.696} = \underline{1.725}$.

Explosions per minute = 275

Assuming 100% efficiency.

$$.696 = \frac{P \times 3.47 \times 3.14 \times 12.8 \times 275}{12 \times 4 \times 33000}$$

M.E.P. = 28.3#/sq.in. gauge.

CONCLUSIONS

After making the series of tests, tabulating the data, and plotting curves, I investigated the results and arrived at the following conclusions:

1. That a small gasoline engine, with a governor operating on the "hit or miss" principle gives a flickering of the lights which is tiring to the eyes.

2. That keying a fly-wheel to the shaft of the generator,steadies its speed, making a constant voltage, which produces a bright light.

3. That the engine uses more gasoline in #s/Hr., with a generator load without fly-wheel or with the Prony brake,than with the generator and fly-wheel.

4. That the minimum gasoline consumption for the Prony brake load is .953 #s/B.H.P./Hr. and for the generator load, with and without a fly-wheel, is 2. #s/B.H.P./Hr.

5. That the M.E.P. of the engine with a brake load is 54#s/sq.in., with the generator load, without the fly-wheel 42#s/sq.in., with the fly-wheel 33#s/sq.in.

6. That the M.E.P. varies inversely proportional with the E.P.M.

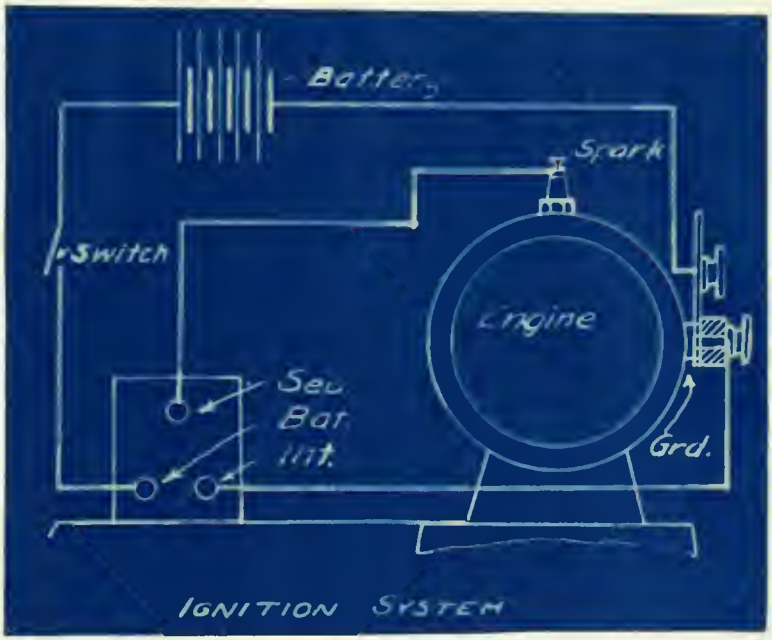

Battery
Spark
Switch
Engine
Sec.
Bat.
Ter.
Grd.
IGNITION SYSTEM

Fig. 1.

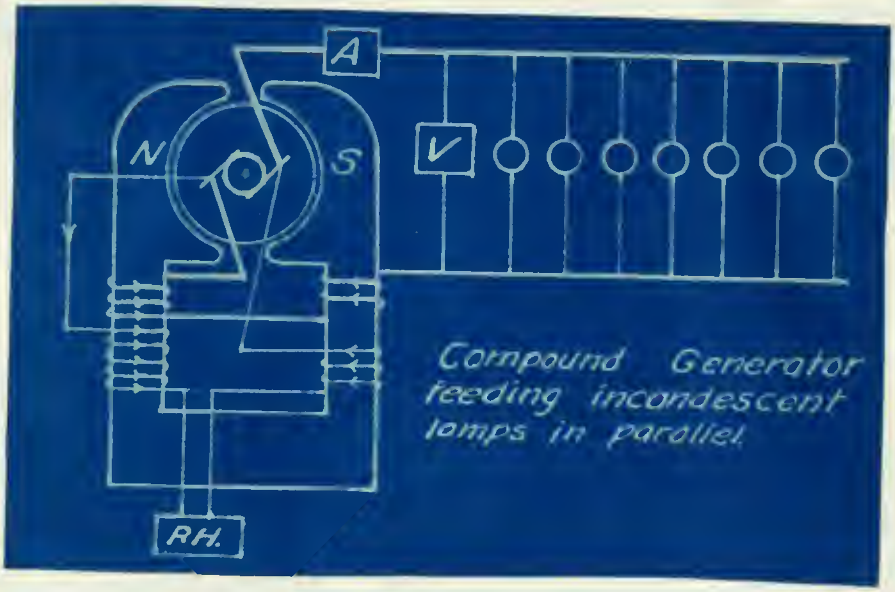

A
N
S
V
R.H.
Compound Generator feeding incandescent lamps in parallel.

Fig. 2.

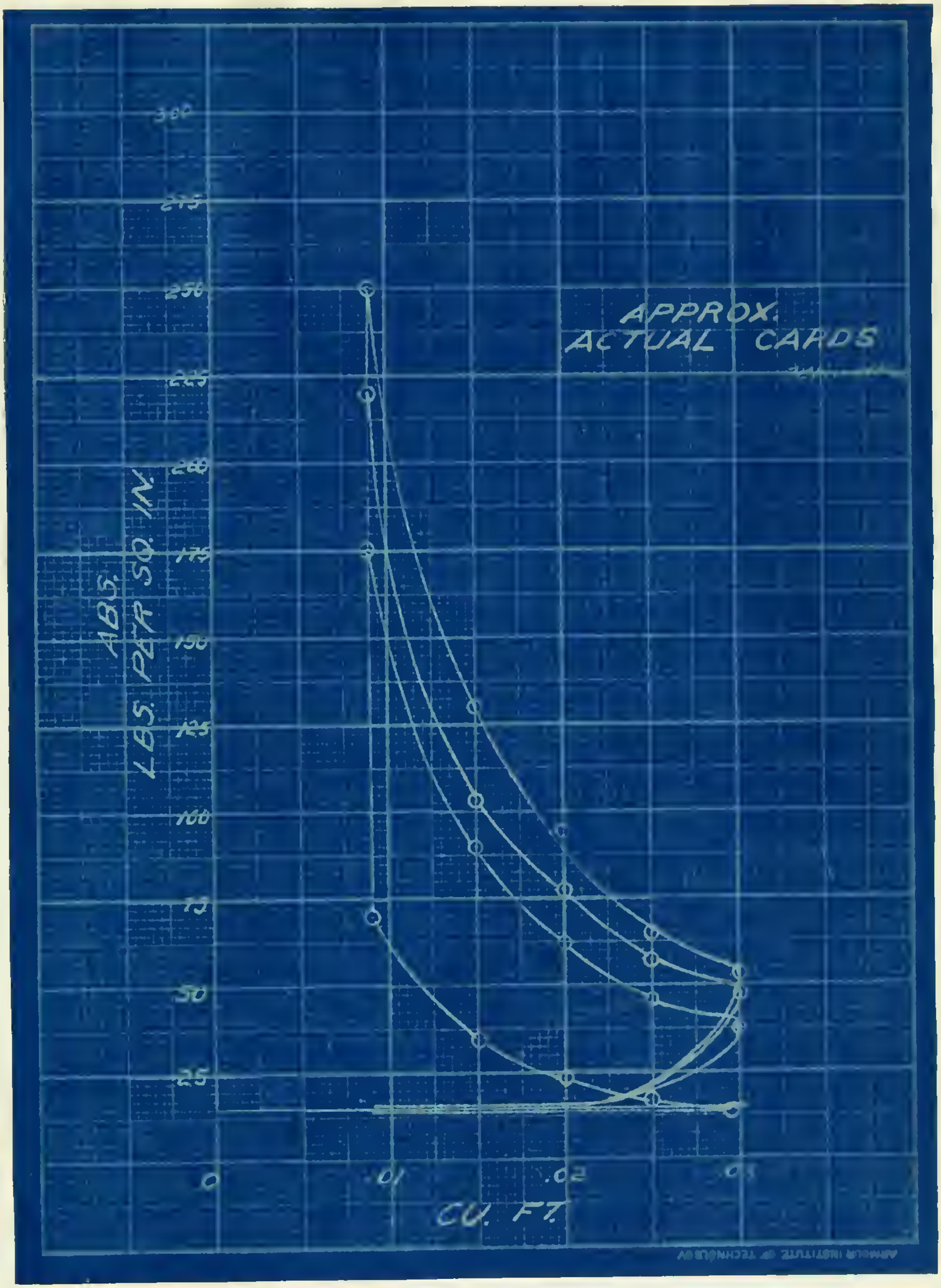

APPROX. ACTUAL CARDS
ABS. LBS. PER SQ. IN.
300
275
250
225
200
175
150
125
100
75
50
25
0
.01
.02
.03
CU. FT.

Fig. 3.

Fig. 4.

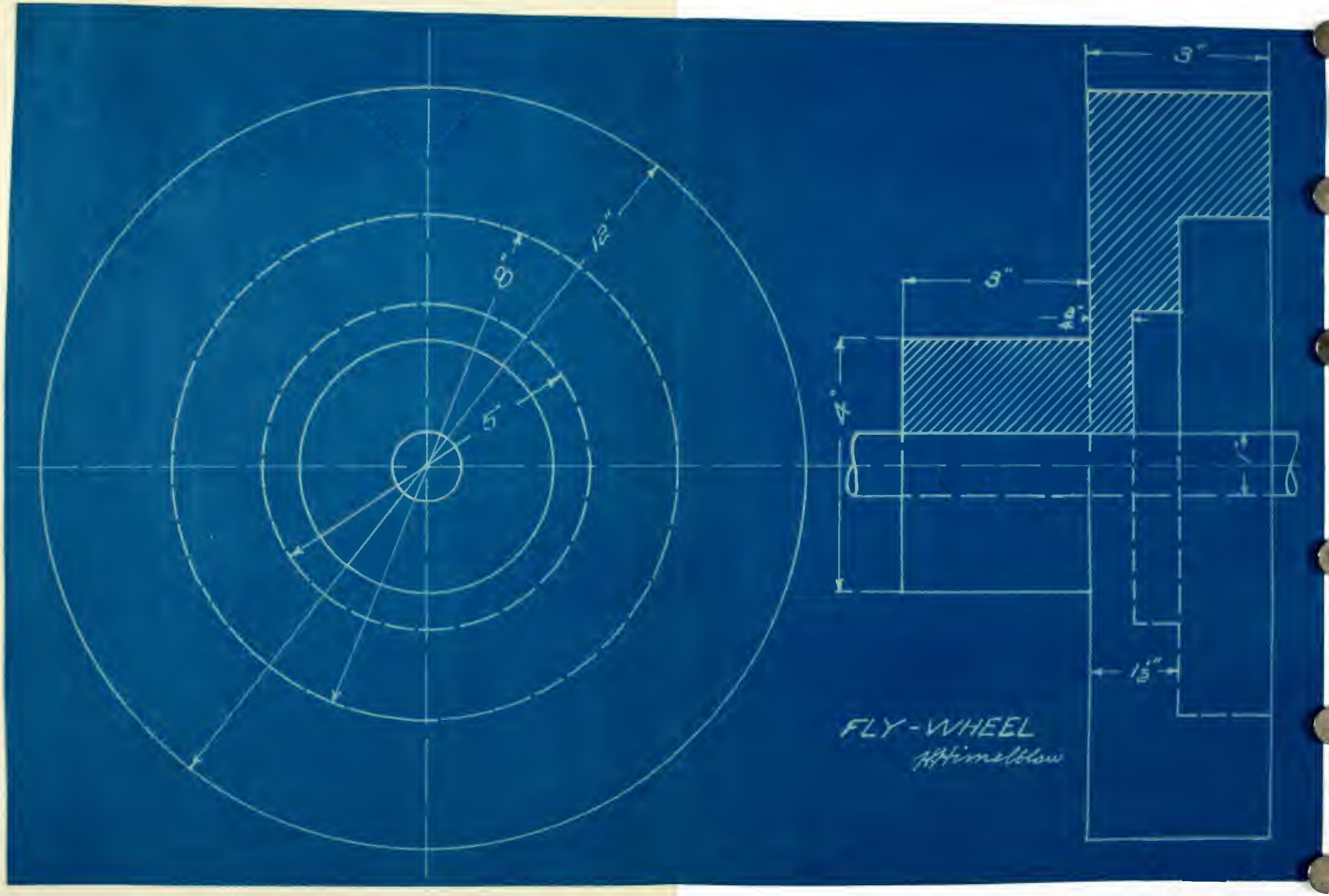
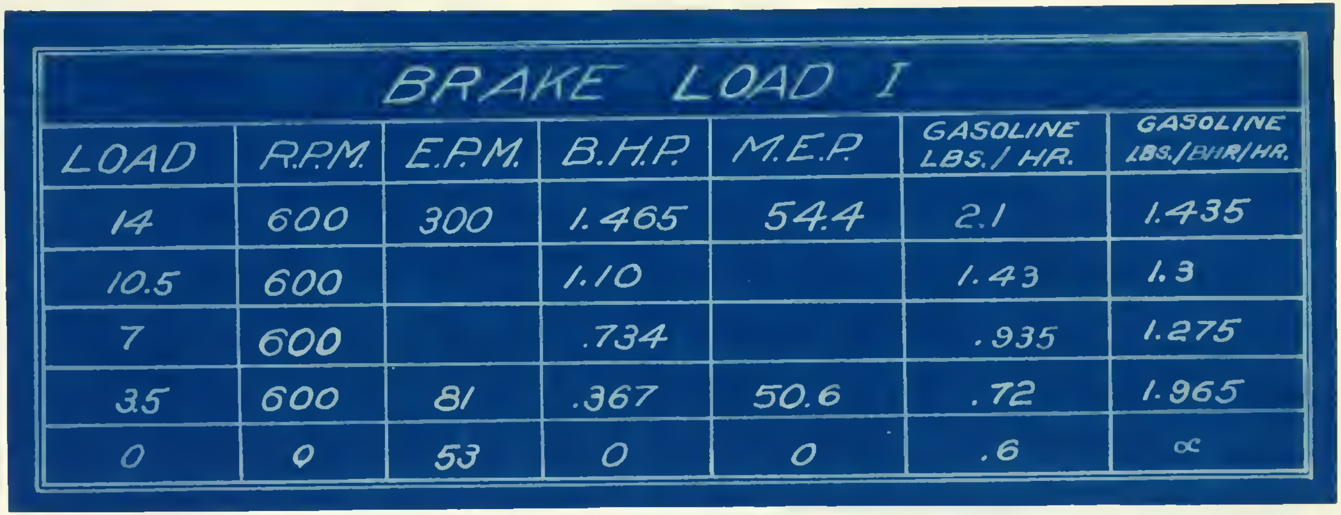


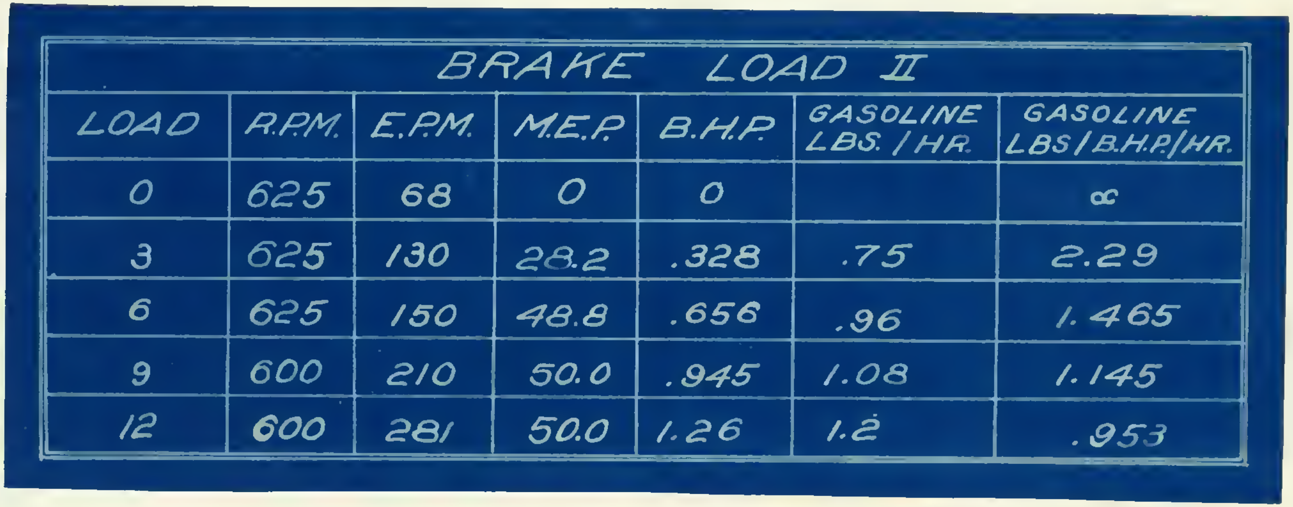
Fig. 4.



BRAKE LOAD I

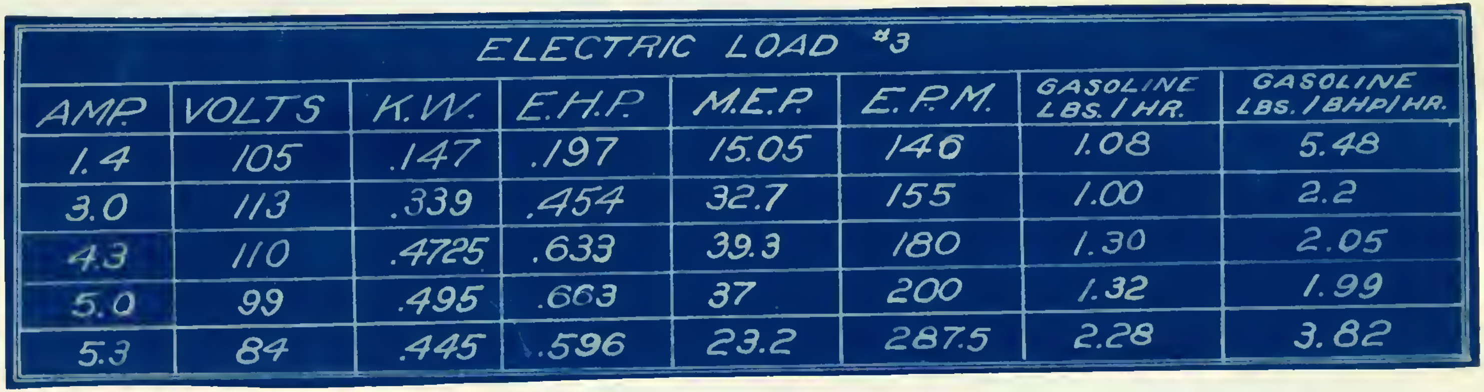
LOAD	R.P.M.	E.P.M.	B.H.P.	M.E.P.	GASOLINE LBS./HR.	GASOLINE LBS./BHP/HR.
14	600	300	1.465	54.4	2.1	1.435
10.5	600		1.10		1.43	1.3
7	600		.734		.935	1.275
3.5	600	81	.367	50.6	.72	1.965
0	0	53	0	0	.6	∝

Fig. 5.



BRAKE LOAD II						
LOAD	R.P.M.	E.P.M.	M.E.P.	B.H.P.	GASOLINE LBS. / HR.	GASOLINE LBS / B.H.P. / HR.
0	625	68	0	0		∞
3	625	130	28.2	.328	.75	2.29
6	625	150	48.8	.656	.96	1.465
9	600	210	50.0	.945	1.08	1.145
12	600	281	50.0	1.26	$1.\dot{2}$	.953

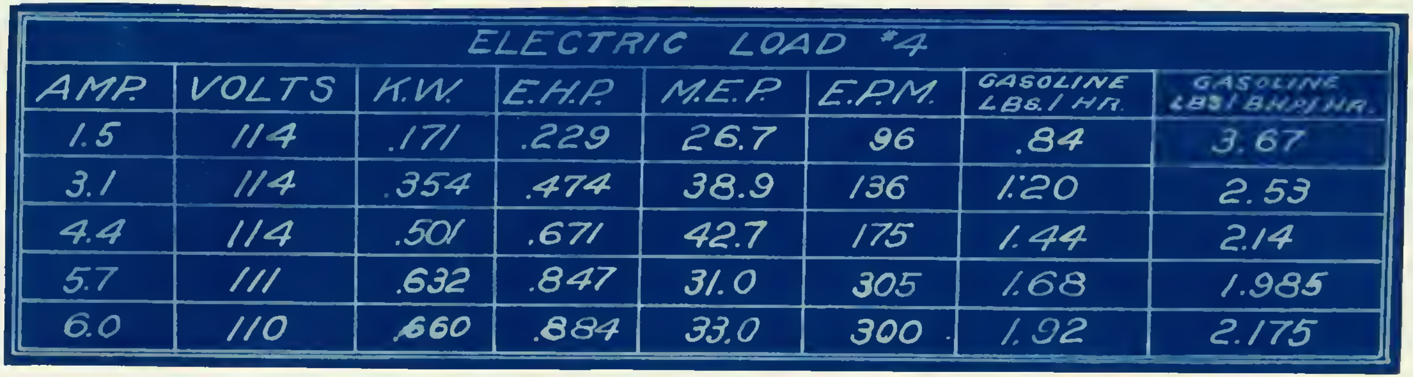
Fig. 6.



ELECTRIC LOAD #3

AMP.	VOLTS	K.W.	E.H.P.	M.E.P.	E.P.M.	GASOLINE LBS./HR.	GASOLINE LBS./BHP/HR.
1.4	105	.147	.197	15.05	146	1.08	5.48
3.0	113	.339	.454	32.7	155	1.00	2.2
4.3	110	.4725	.633	39.3	180	1.30	2.05
5.0	99	.495	.663	37	200	1.32	1.99
5.3	84	.445	.596	23.2	287.5	2.28	3.82

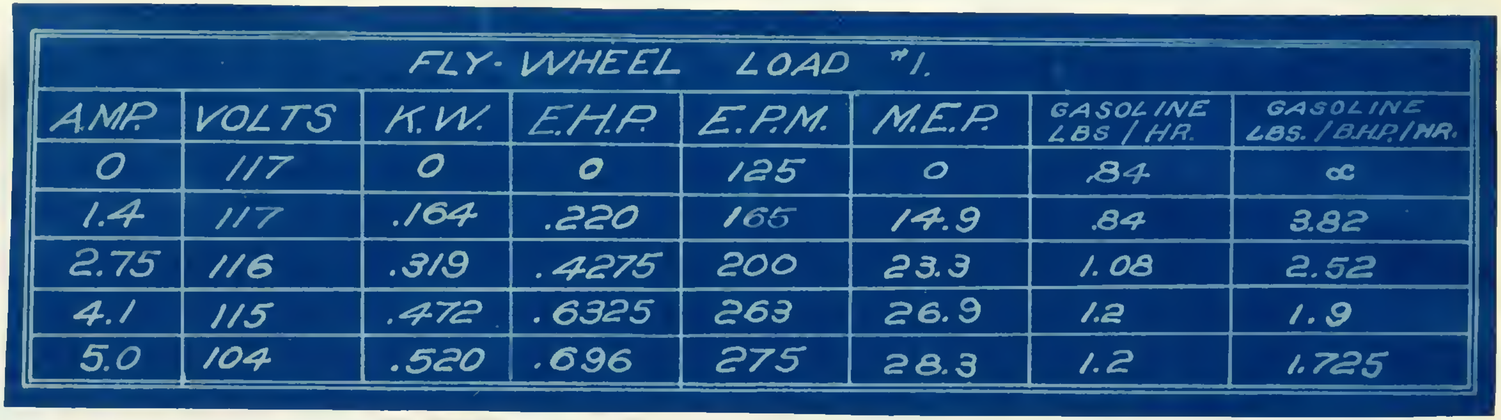
Fig. 7.



ELECTRIC LOAD #4

AMP.	VOLTS	K.W.	E.H.P.	M.E.P.	E.P.M.	GASOLINE LBS./HR.	GASOLINE LBS/B.H.P./HR.
1.5	114	.171	.229	26.7	96	.84	3.67
3.1	114	.354	.474	38.9	136	1.20	2.53
4.4	114	.501	.671	42.7	175	1.44	2.14
5.7	111	.632	.847	31.0	305	1.68	1.985
6.0	110	.660	.884	33.0	300	1.92	2.175

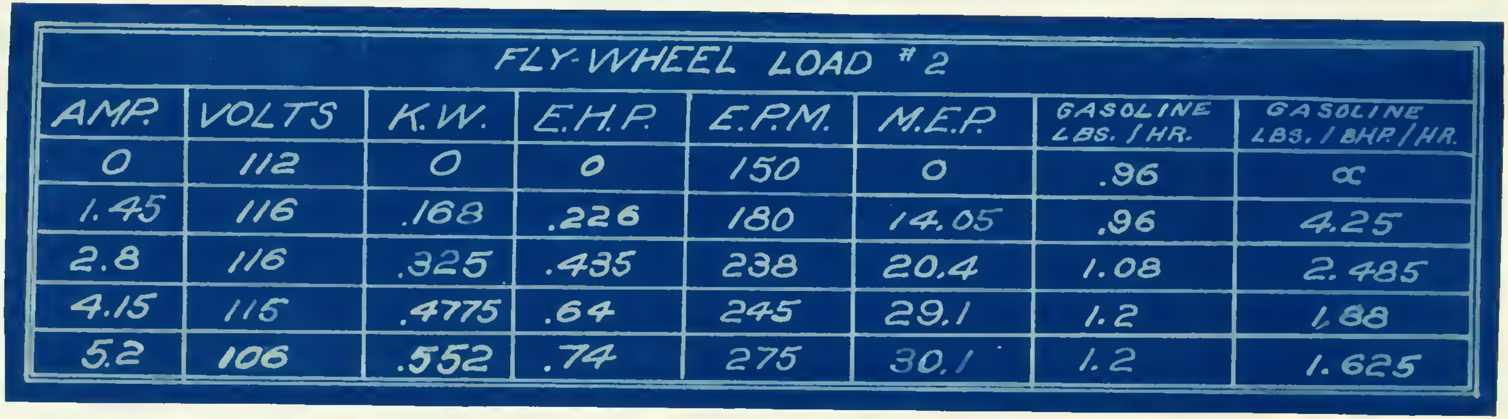
Fig. 8.



FLY-WHEEL LOAD #1.

AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS / HR.	GASOLINE LBS. / B.H.P. / HR.
0	117	0	0	125	0	.84	∞
1.4	117	.164	.220	165	14.9	.84	3.82
2.75	116	.319	.4275	200	23.3	1.08	2.52
4.1	115	.472	.6325	263	26.9	1.2	1.9
5.0	104	.520	.696	275	28.3	1.2	1.725

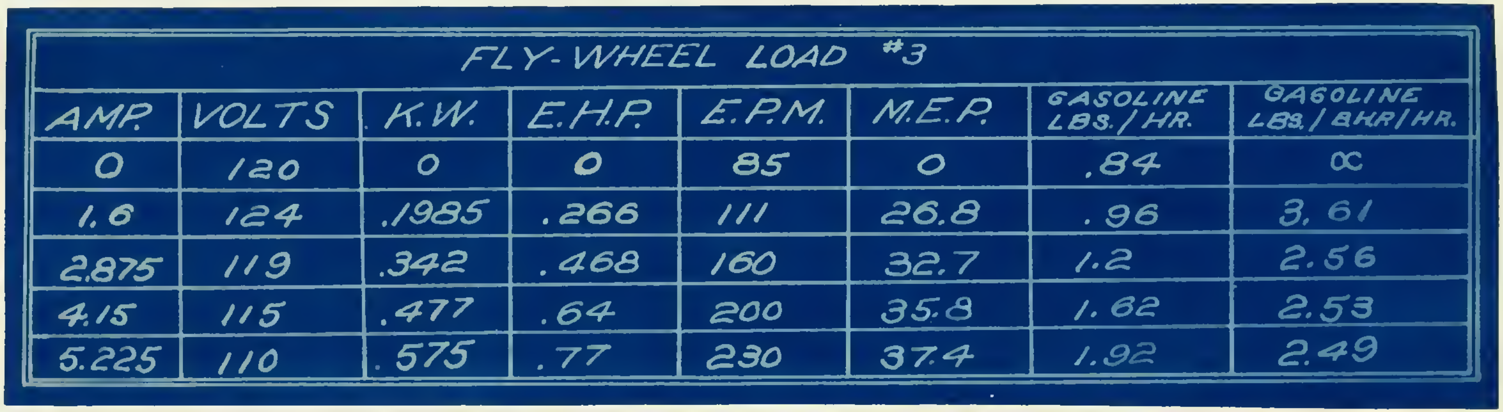
Fig. 9.



FLY-WHEEL LOAD # 2

AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS. / HR.	GASOLINE LBS. / BHP. / HR.
0	112	0	0	150	0	.96	∞
1.45	116	.168	.226	180	14.05	.96	4.25
2.8	116	.325	.435	238	20.4	1.08	2.485
4.15	115	.4775	.64	245	29.1	1.2	1,88
5.2	106	.552	.74	275	30.1	1.2	1.625

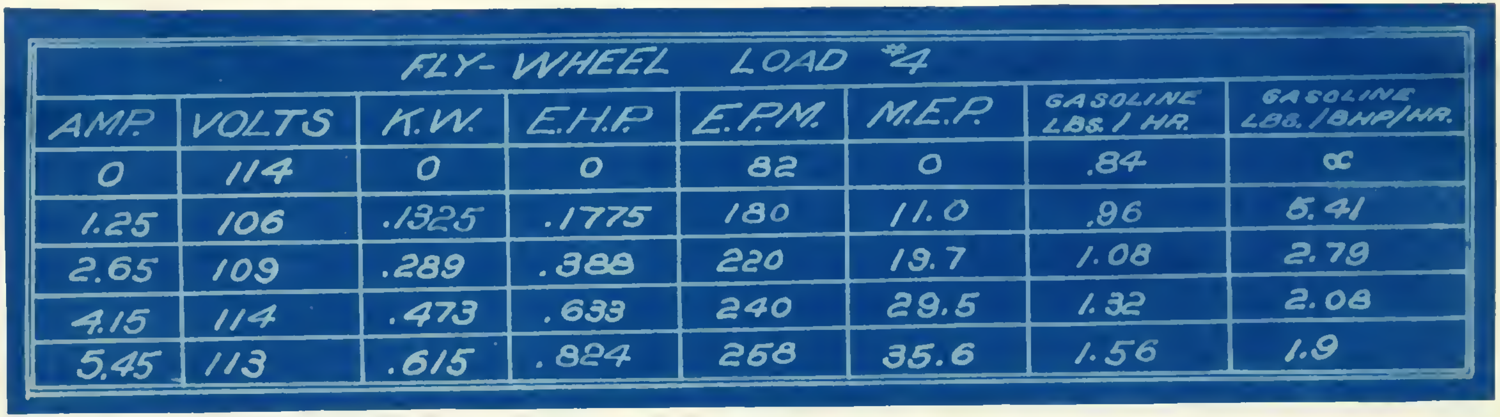
Fig. 10.



FLY-WHEEL LOAD #3

AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS./HR.	GASOLINE LBS./BHP/HR.
0	120	0	0	85	0	.84	∞
1.6	124	.1985	.266	111	26.8	.96	3.61
2.875	119	.342	.468	160	32.7	1.2	2.56
4.15	115	.477	.64	200	35.8	1.62	2.53
5.225	110	.575	.77	230	37.4	1.92	2.49

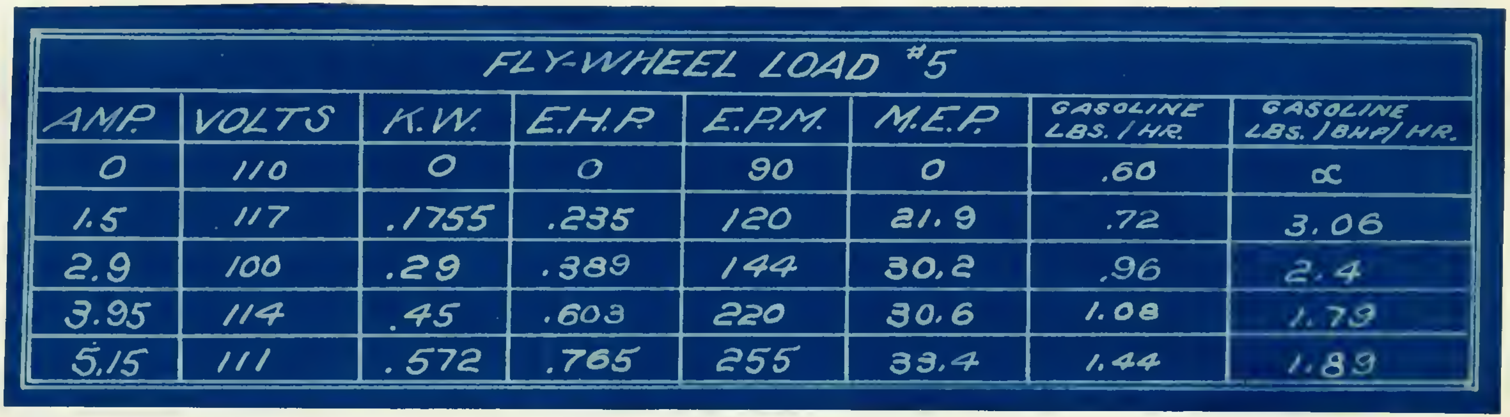
Fig. 11.



FLY- WHEEL LOAD #4

AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS. / HR.	GASOLINE LBS. / BHP / HR.
0	114	0	0	82	0	.84	∞
1.25	106	.1325	.1775	180	11.0	.96	5.41
2.65	109	.289	.388	220	19.7	1.08	2.79
4.15	114	.473	.633	240	29.5	1.32	2.08
5.45	113	.615	.824	268	35.6	1.56	1.9

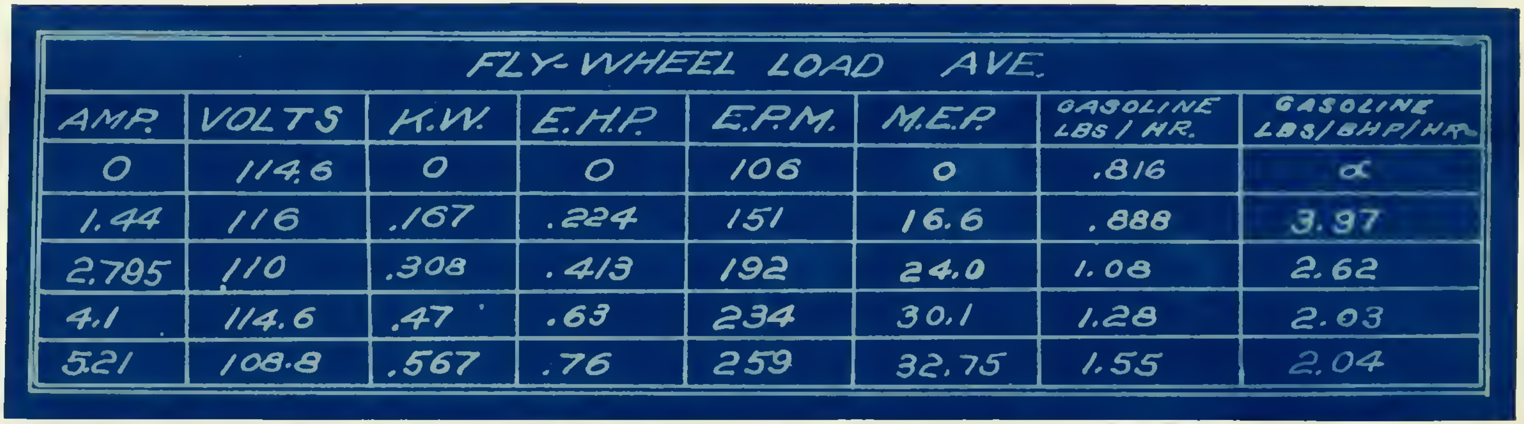
Fig. 12.



FLY-WHEEL LOAD #5

AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS. / HR.	GASOLINE LBS. / BHP / HR.
0	110	0	0	90	0	.60	∞
1.5	117	.1755	.235	120	21.9	.72	3.06
2.9	100	.29	.389	144	30.2	.96	2.4
3.95	114	.45	.603	220	30.6	1.08	1.79
5.15	111	.572	.765	255	33.4	1.44	1.89

Fig. 13.



FLY-WHEEL LOAD AVE.							
AMP.	VOLTS	K.W.	E.H.P.	E.P.M.	M.E.P.	GASOLINE LBS / HR.	GASOLINE LBS/BHP/HR.
0	114.6	0	0	106	0	.816	α
1.44	116	.167	.224	151	16.6	.888	3.97
2.795	110	.308	.413	192	24.0	1.08	2.62
4.1	114.6	.47	.63	234	30.1	1.28	2.03
5.21	108.8	.567	.76	259	32.75	1.55	2.04

Fig. 14.

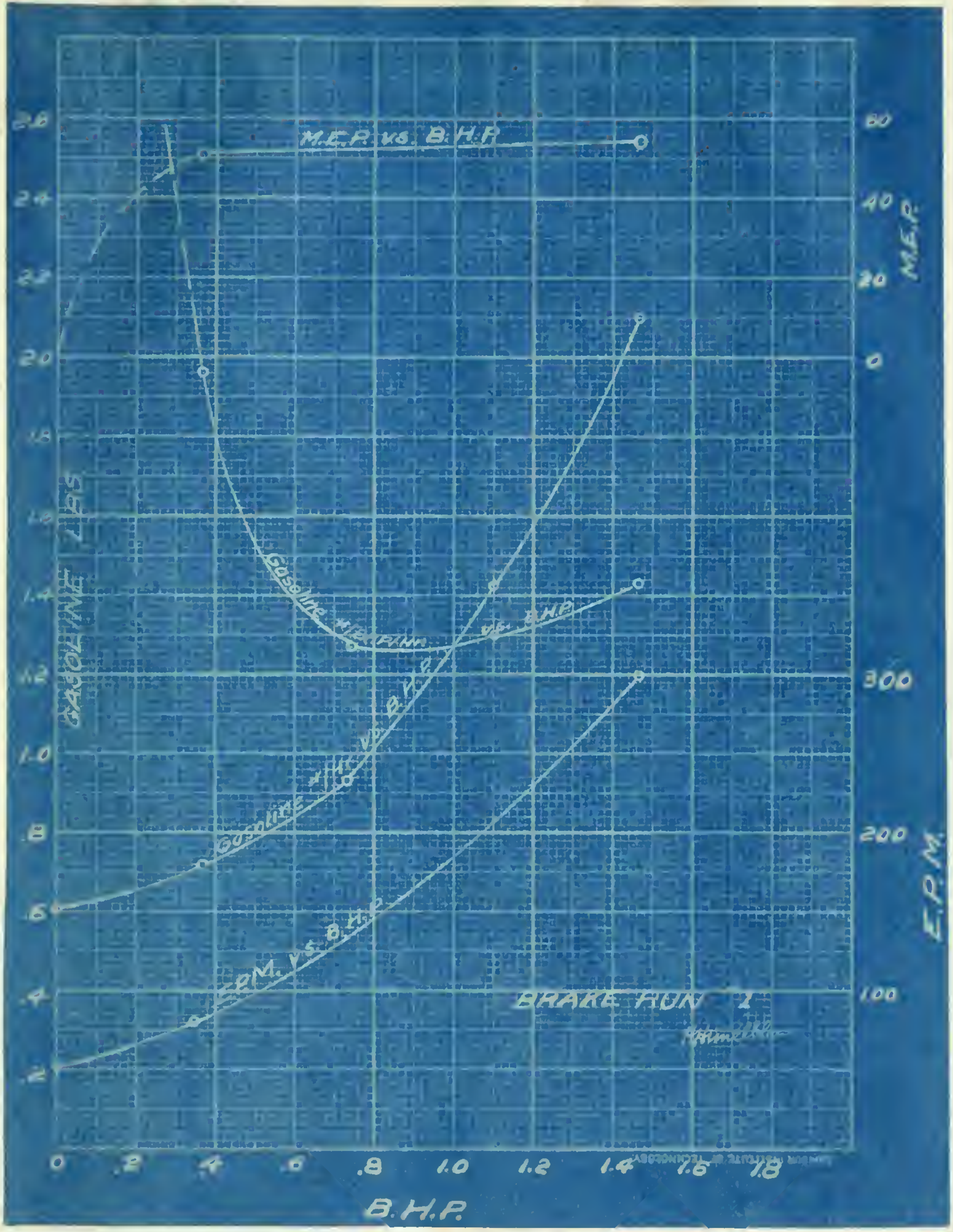

M.E.P. vs. B.H.P.
Gasoline per B.H.P. Hr. vs. B.H.P.
Gasoline per Hr. vs. B.H.P.
R.P.M. vs. B.H.P.
BRAKE RUN I
GASOLINE LBS.
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
M.E.P.
60
40
20
0
R.P.M.
300
200
100
B.H.P.
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8

Fig. 15.

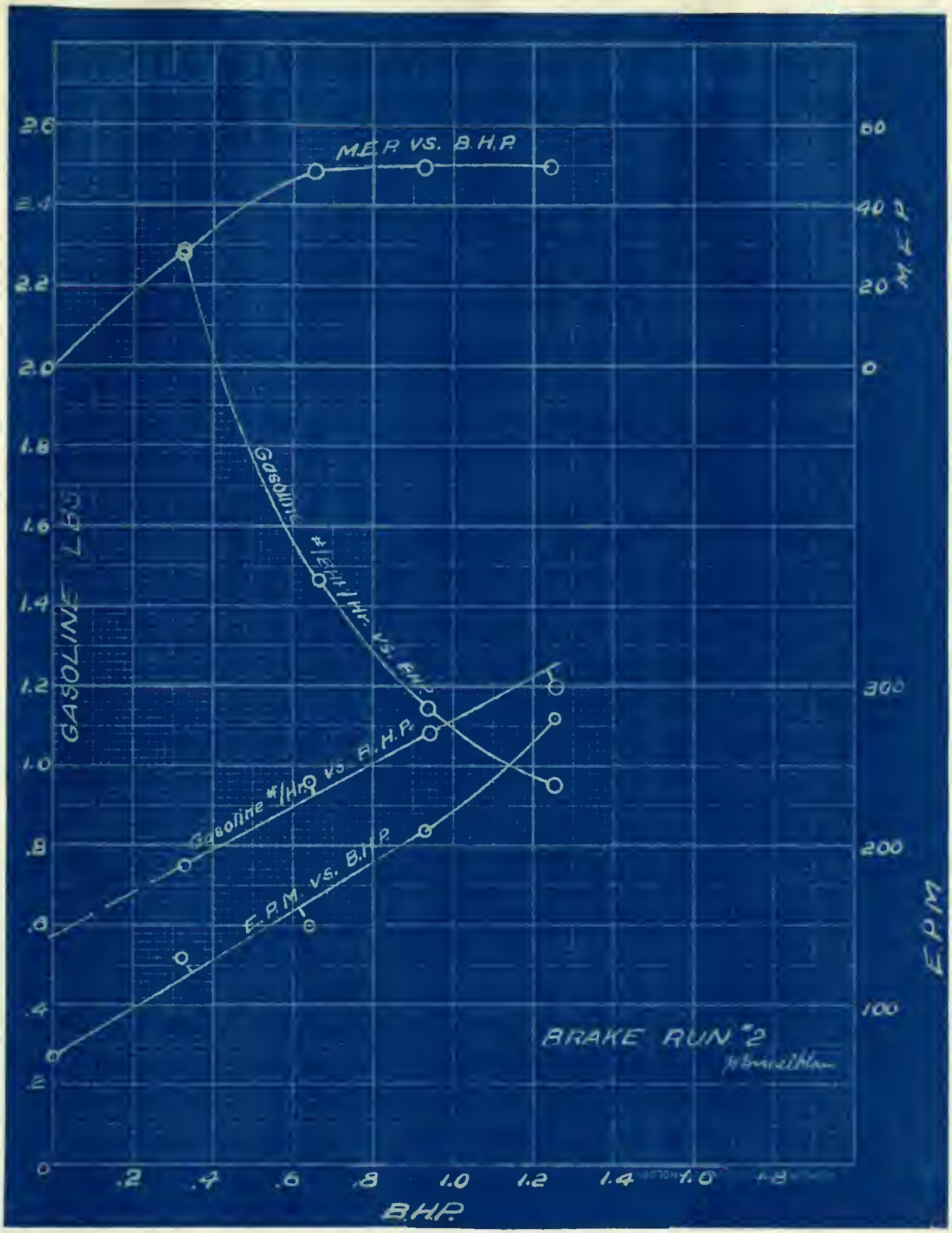

M.E.P. VS. B.H.P.
Gasoline #/E.H.P./Hr. vs. B.H.P.
Gasoline #/Hr. vs. B.H.P.
E.P.M. vs. B.H.P.
GASOLINE LBS.
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
M.E.P.
60
40
20
0
E.P.M.
300
200
100
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
B.H.P.
BRAKE RUN #2

Fig. 16.

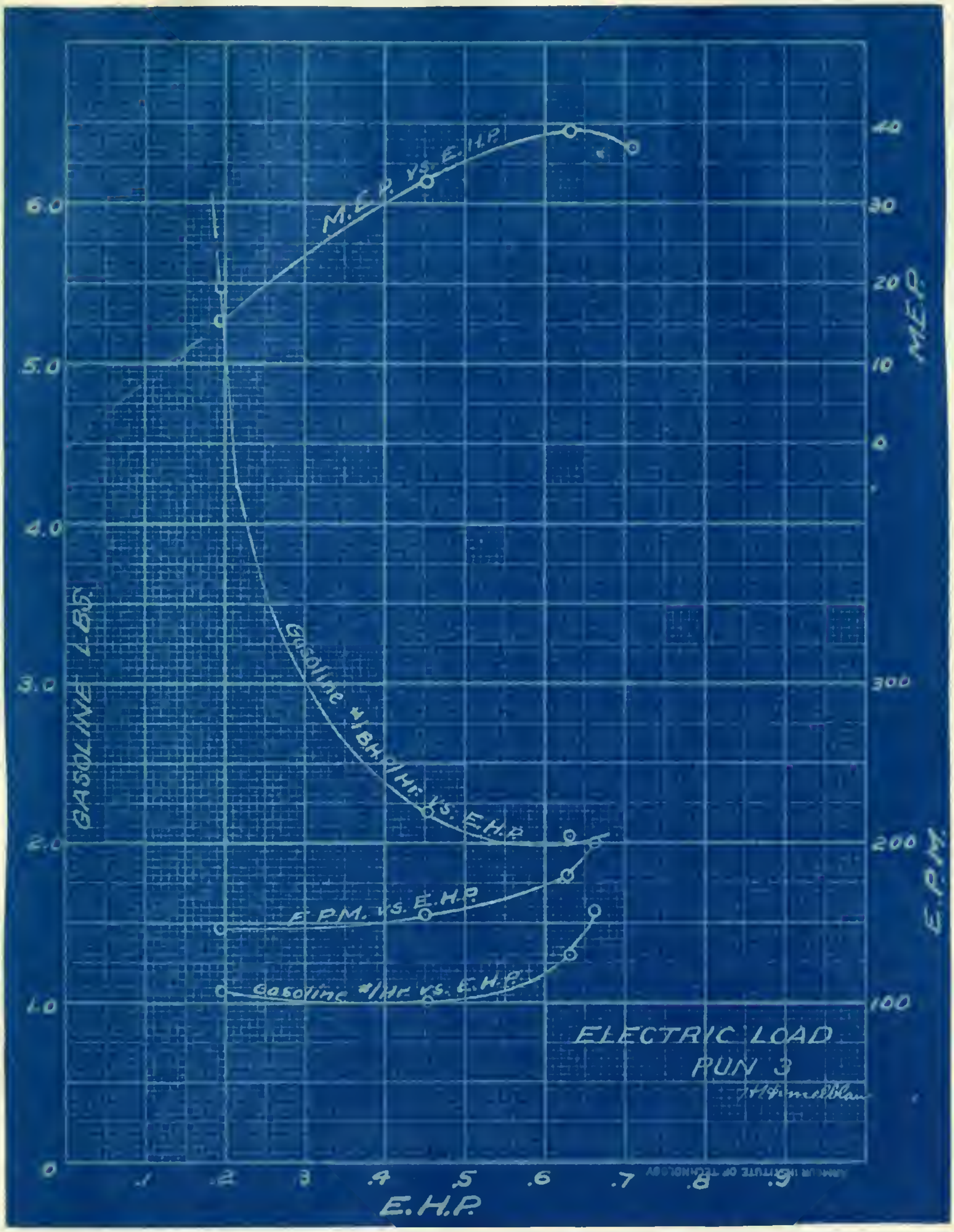

M.E.P. vs. E.H.P.
Gasoline #/B.H.P./Hr. vs. E.H.P.
E.P.M. vs. E.H.P.
Gasoline #/Hr. vs. E.H.P.
ELECTRIC LOAD
RUN 3
GASOLINE LBS.
6.0
5.0
4.0
3.0
2.0
1.0
0
M.E.P.
40
30
20
10
0
E.P.M.
300
200
100
.1
.2
.3
.4
.5
.6
.7
.8
.9
E.H.P.
ARMOUR INSTITUTE OF TECHNOLOGY

Fig. 17.

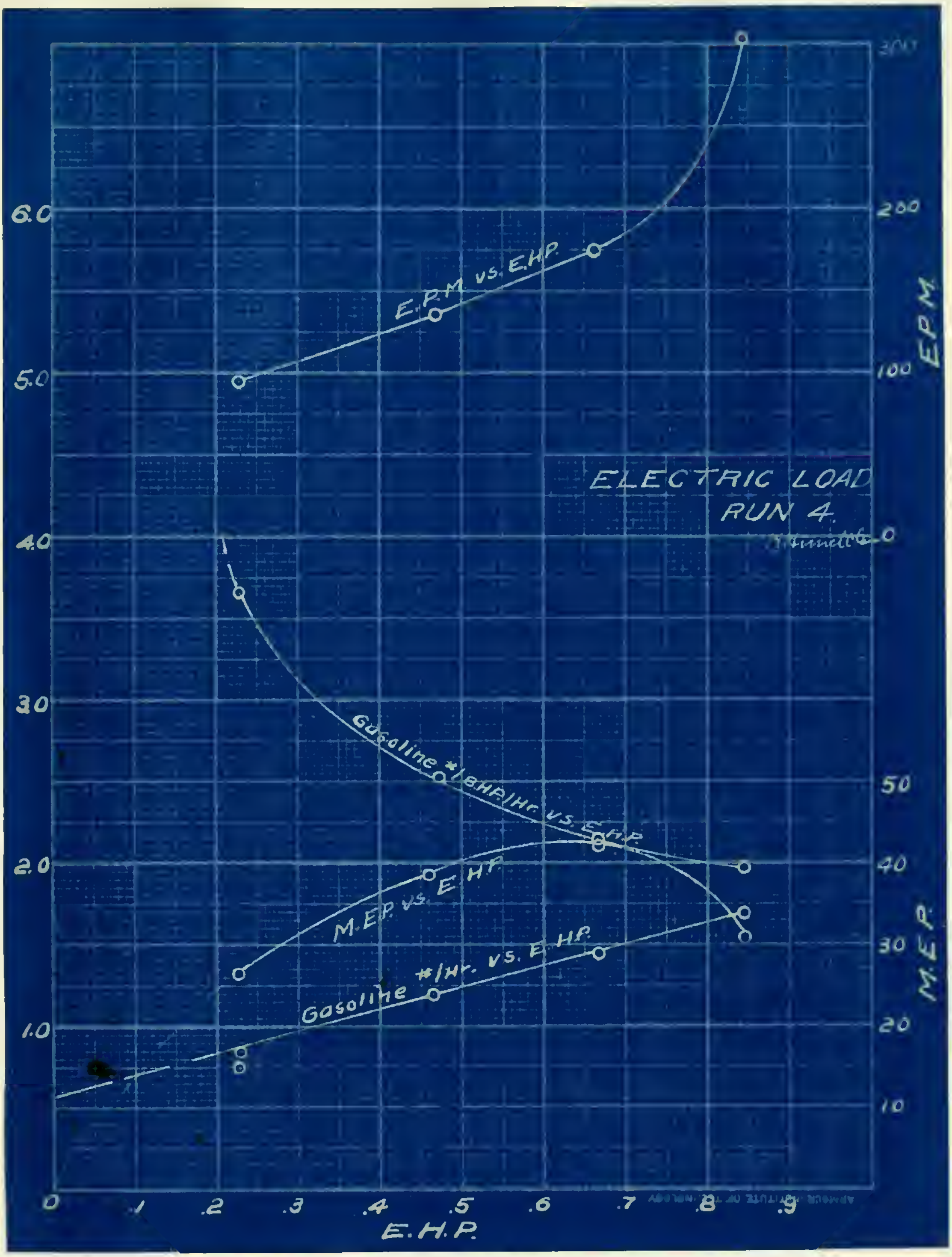

ELECTRIC LOAD
RUN 4.
E.P.M. vs. E.H.P.
Gasoline #/EHP/Hr. vs. E.H.P.
M.E.P. vs. E.H.P.
Gasoline #/Hr. vs. E.H.P.
6.0
5.0
4.0
3.0
2.0
1.0
300
200
100
0
50
40
30
20
10
EPM
M.E.P.
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
E.H.P.

Fig. 18.

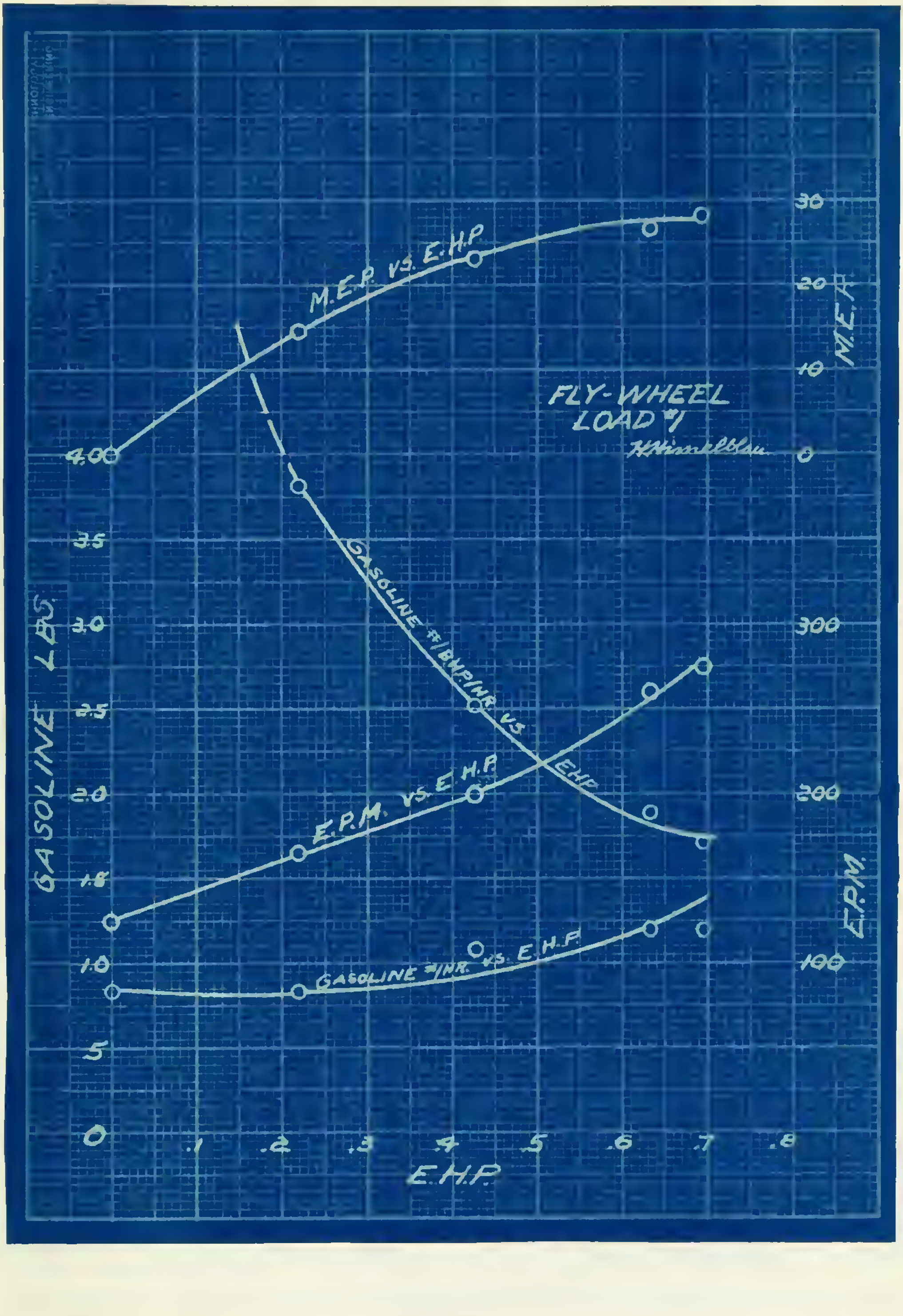

M.E.P. vs. E.H.P.
GASOLINE #/BHP/HR. vs. E.H.P.
E.P.M. vs. E.H.P.
GASOLINE #/HR. vs. E.H.P.
FLY-WHEEL
LOAD #1
H Himmelblau
GASOLINE LBS.
4.00
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
M.E.P.
30
20
10
0
E.P.M.
300
200
100
0
.1
.2
.3
.4
.5
.6
.7
.8
E.H.P.

Fig. 19.

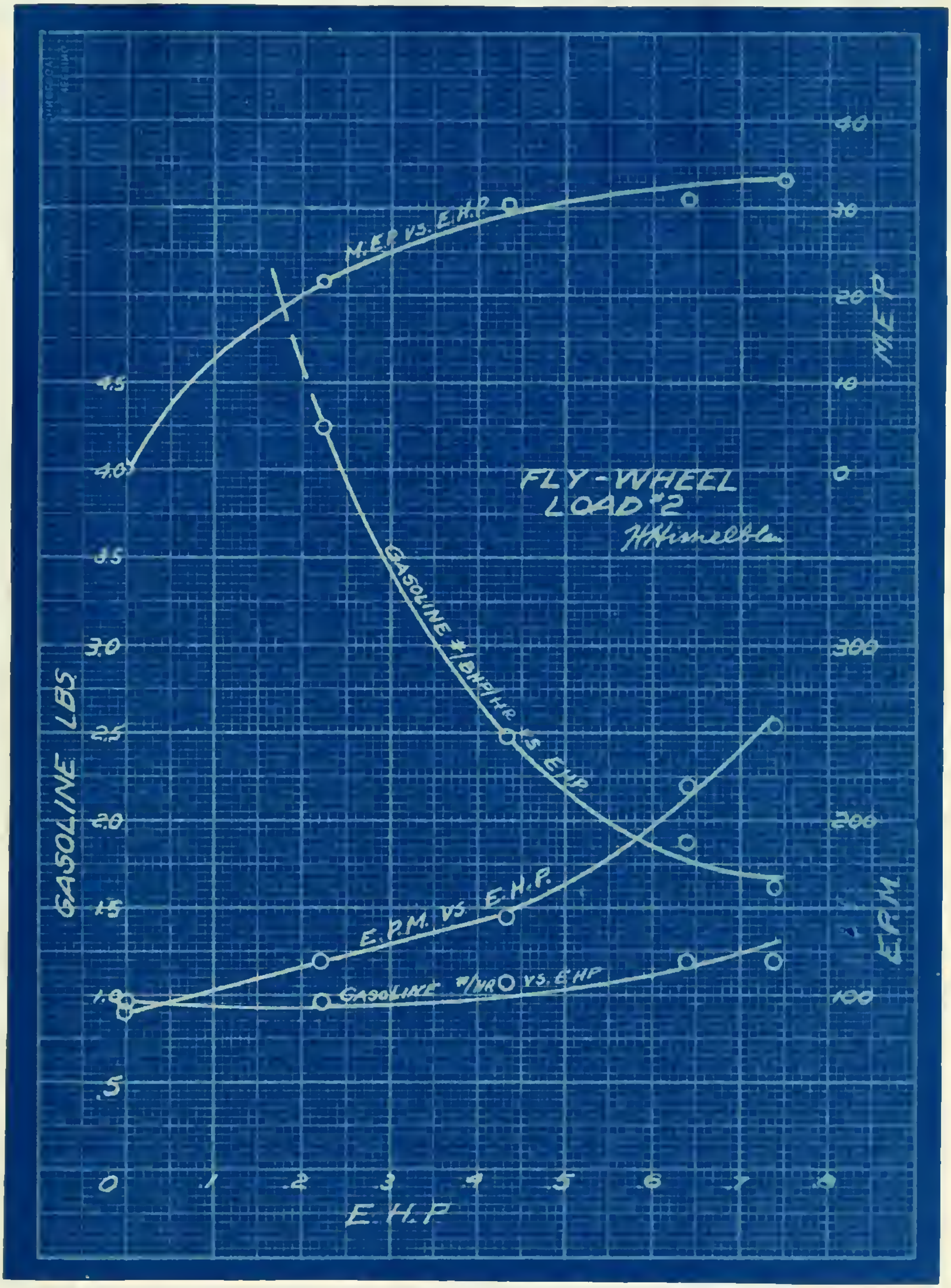

FLY-WHEEL
LOAD #2
M.E.P. VS. E.H.P.
GASOLINE #/BHP/HR VS. E.H.P.
E.P.M. VS. E.H.P.
GASOLINE #/HR VS. E.H.P.
GASOLINE LBS
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
.1
.2
.3
.4
.5
.6
.7
.8
E.H.P.
M.E.P.
40
30
20
10
0
E.P.M.
300
200
100

FIG. 20.

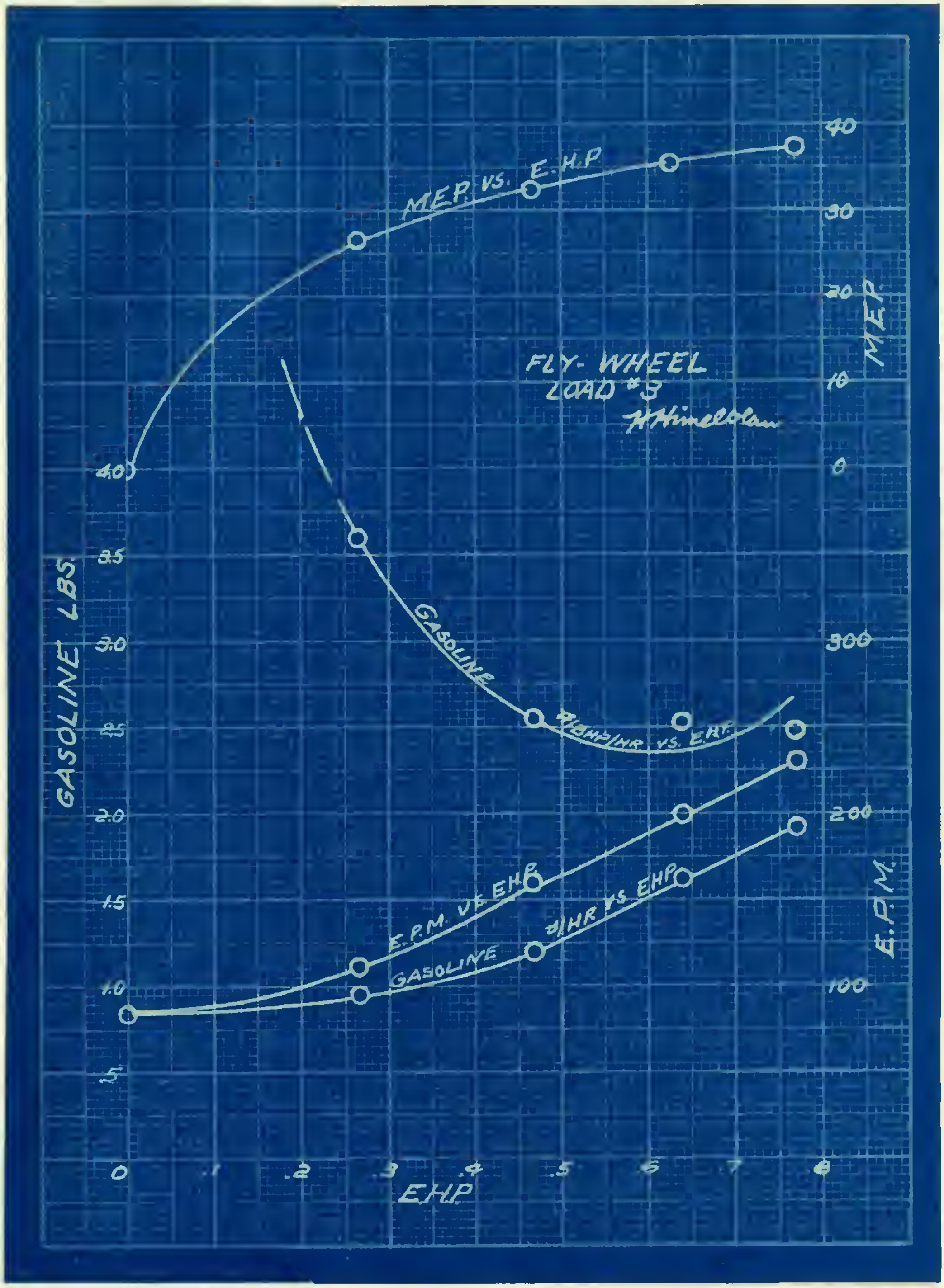

MEP VS. E.H.P
FLY-WHEEL
LOAD #3
H Himelblau
GASOLINE #/BHP/HR VS. E.H.P.
E.P.M. VS. E.H.P.
GASOLINE #/HR VS. EHP
GASOLINE LBS
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
.1
.2
.3
.4
.5
.6
.7
.8
EHP
40
30
20
10
0
MEP
300
200
100
E.P.M.

Fig. 21.

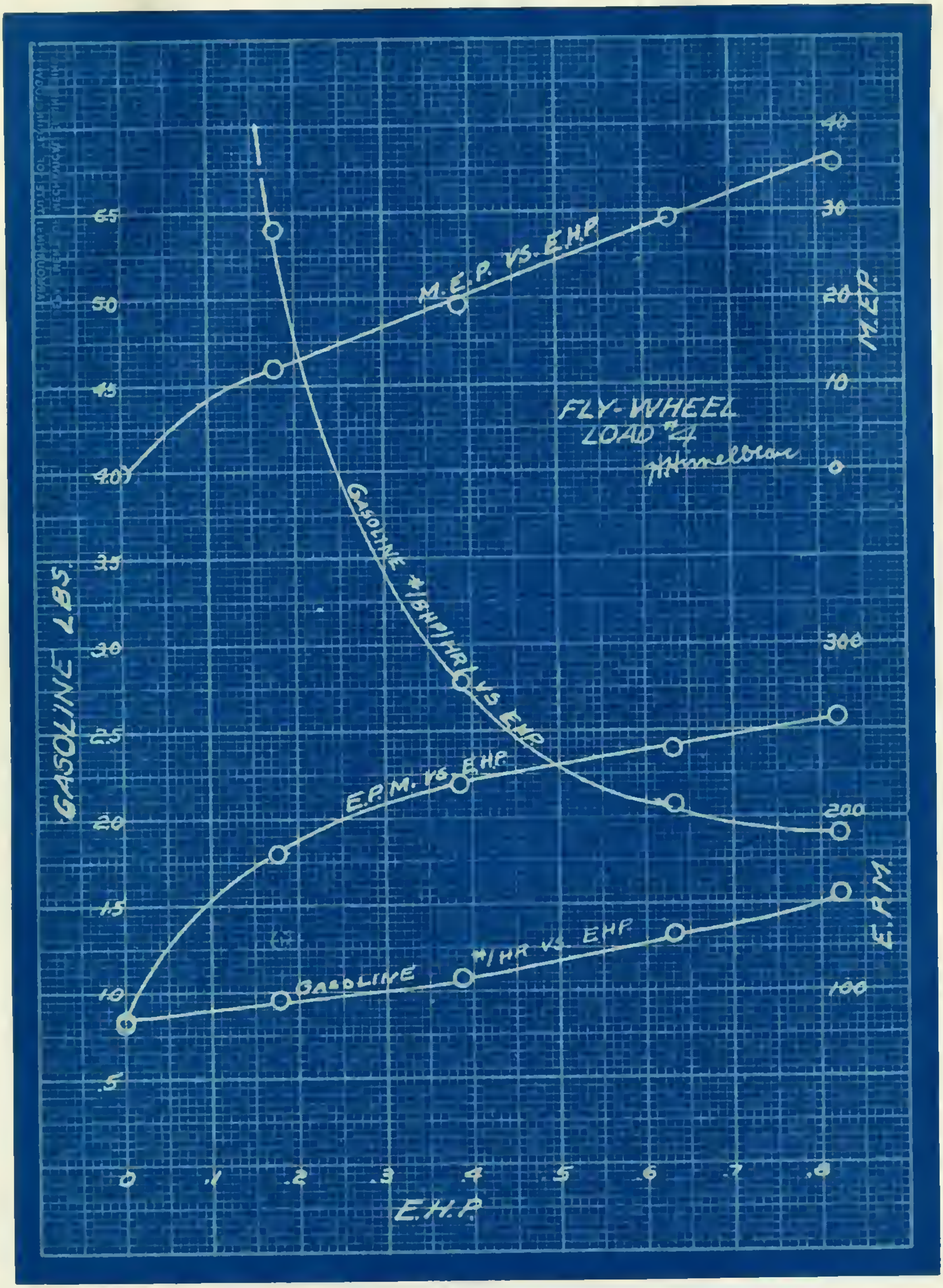

40
30
20
10
0
M.E.P.
M.E.P. VS. E.H.P.
65
50
45
40
35
30
25
20
15
10
5
GASOLINE LBS.
FLY-WHEEL
LOAD #4
GASOLINE #/BHP/HR VS E.H.P.
300
200
100
E.P.M. VS. E.H.P.
E.P.M.
GASOLINE #/HR VS EHP
0
.1
.2
.3
.4
.5
.6
.7
.8
E.H.P.

Fig. 22.

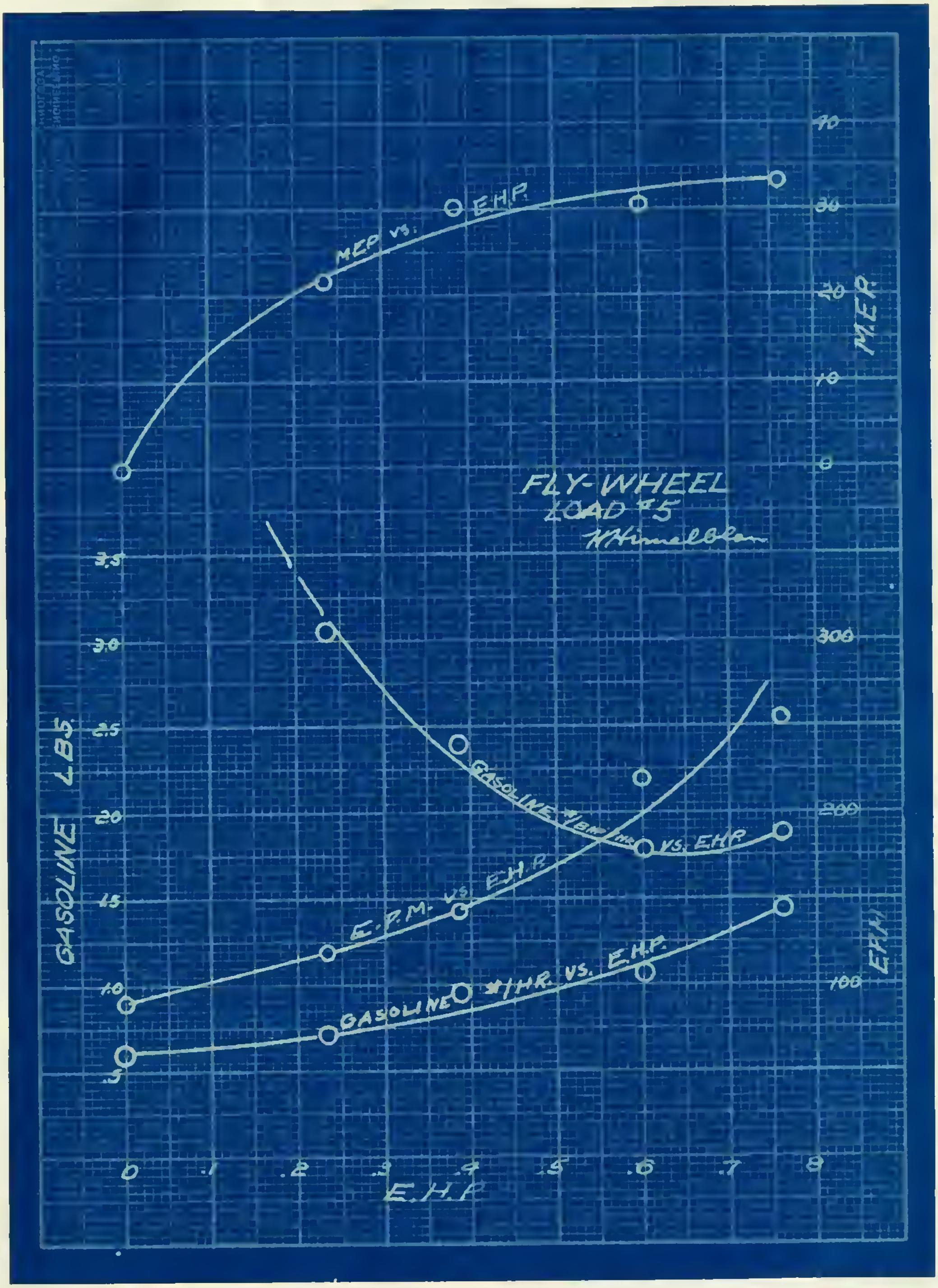

FLY-WHEEL
LOAD #5
W. Himmelblau
MEP VS. E.H.P.
GASOLINE #/BHP. HR. VS. EHP
E.P.M. VS. E.H.P.
GASOLINE #/HR. VS. E.H.P.
GASOLINE LBS
M.E.P.
E.P.M.
E.H.P.
0
.1
.2
.3
.4
.5
.6
.7
.8
.5
1.0
1.5
2.0
2.5
3.0
3.5
0
10
20
30
40
100
200
300

Fig. 23.

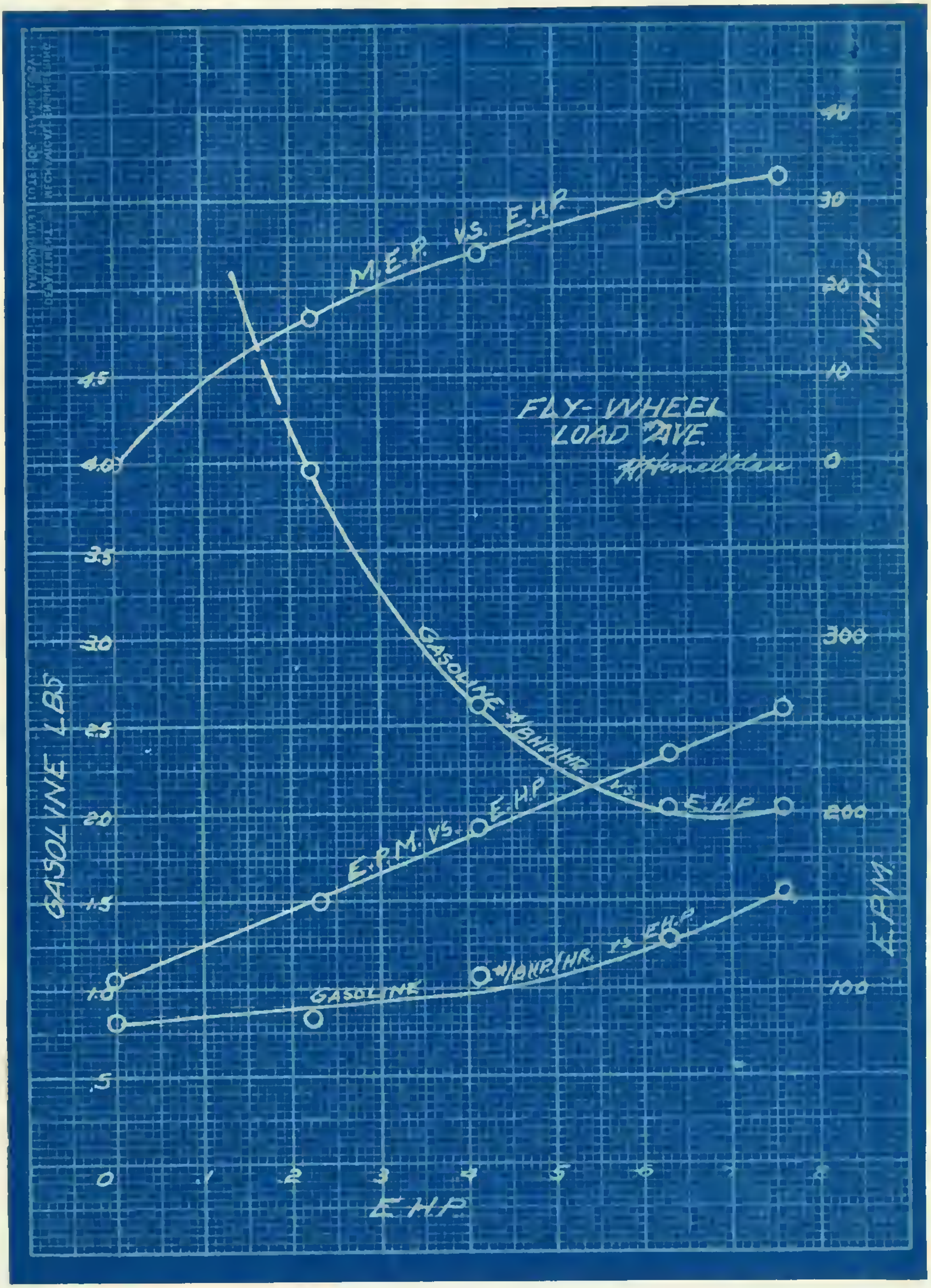

M.E.P. VS. E.H.P.
GASOLINE #/BHP/HR. VS. E.H.P.
E.P.M. VS. E.H.P.
GASOLINE #/BHP/HR. VS E.H.P.
FLY-WHEEL
LOAD "AVE.
GASOLINE LBS
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
1
2
3
4
5
6
7
8
E.H.P.
M.E.P.
40
30
20
10
0
E.P.M.
300
200
100

Fig. 24.

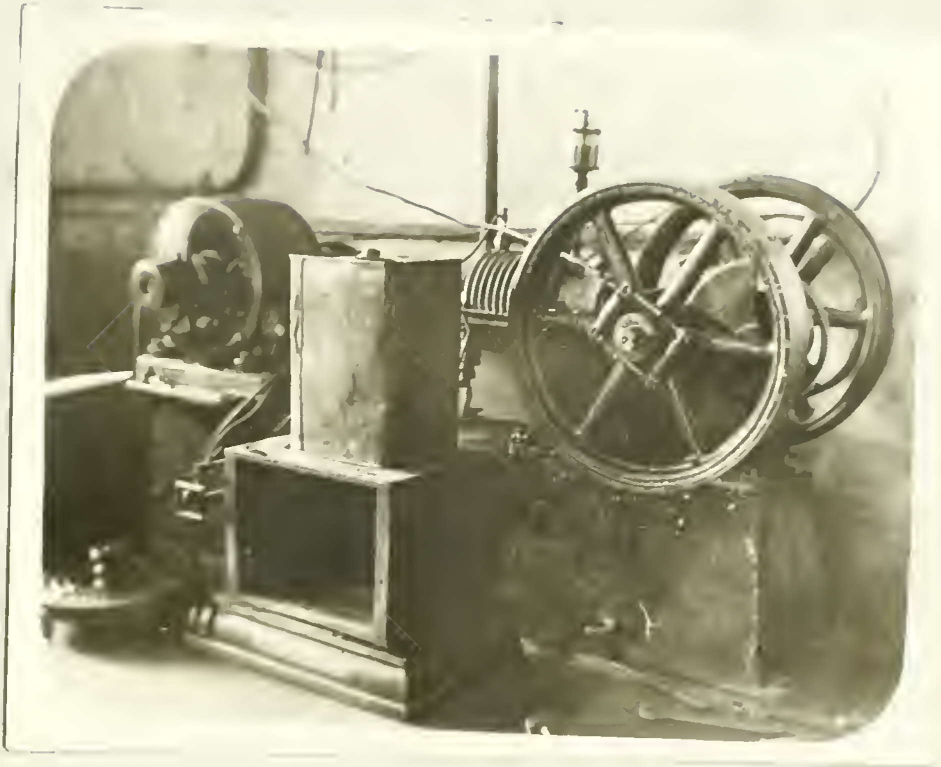


Fig. 25.

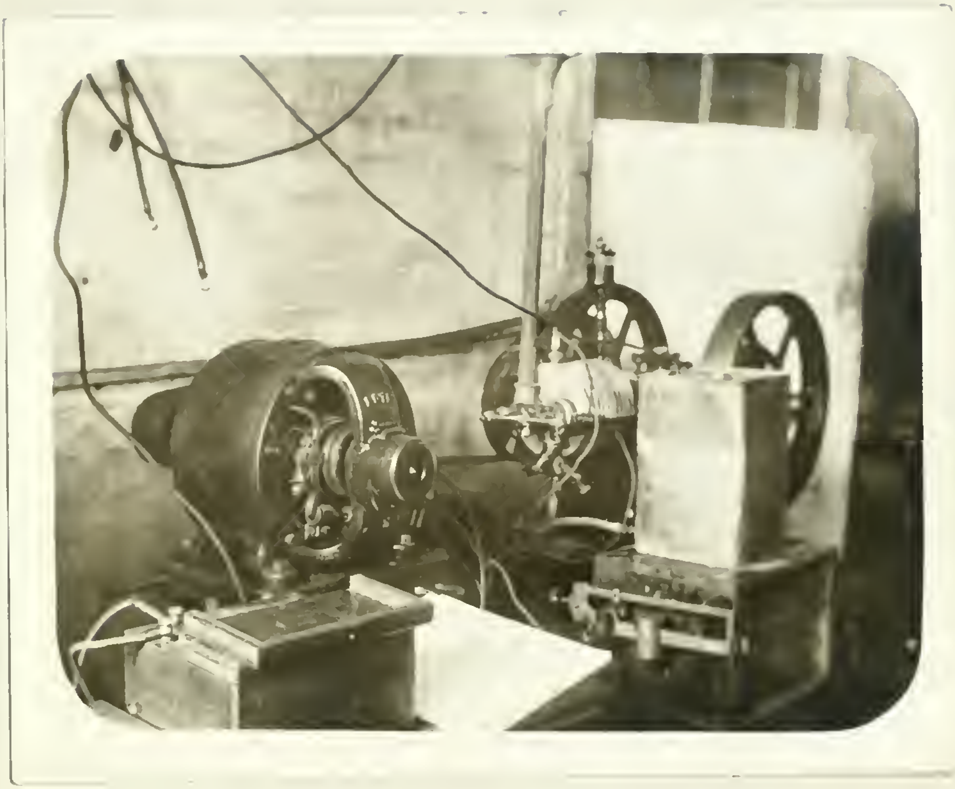


Fig. 26.